REMARKS

Claims 1-9 are pending herein. Claims 10-26 have been cancelled without prejudice or disclaimer. Claim 1 has been amended as supported by Figs. 2a and 2b of the present application. Claims 2 and 3 have been amended for clarification purposes only. Attached hereto as page 10, pursuant to Rule 1.121(c)(1)(ii), is a marked-up version of the amended claims.

Examiner Song and SPE Utech are thanked for courtesies extended to Applicants' undersigned representative during a telephonic interview on October 16, 2002. The substance of that interview has been incorporated into the following remarks.

1. Applicants affirm the provisional election to prosecute claims 1-9. Claims 10-26 have been withdrawn from consideration as being drawn to a non-elected invention, and thus have been cancelled without prejudice or disclaimer. Applicants reserve the right under 35 USC §121 to file a divisional application for the non-elected claims.

2. Claims 1, 2, 4, 6 and 8 were rejected under §102(b) over Imaeda et al. To the extent that this rejection might be applied against the amended claims, it is respectfully traversed.

With reference to Figs. 2a and 2b of the present application, amended claim 1 recites, among other things, that a cooling mechanism (e.g., cooling tubes 14A and 14B) is provided to directly cool oxide single crystal 31 while it is being drawn from the opening of crucible 7. The oxide single crystal is directly cooled by flowing cooling medium 16 through an internal portion of cooling tube 14A, which functions to actively remove ambient heat from oxide single crystal 31. Alternatively, cooling medium 16 is blown out of blowing holes 14b directly on the surface of oxide single crystal 31.

Applicants discovered that by controlling the difference in the temperature of portions of oxide single crystal 31 between the opening of crucible 13 and annealing region 20 (shown in Fig. 1) to be within a specified temperature gradient range, the formation of cracks could be suppressed during growth and annealing of the oxide single crystal (page 5, paragraph [0016]-[0019] of the present application).

Imaeda discloses a method of changing the pulling rate of an oxide-series single crystal to control the composition of the single crystal. Imaeda does not disclose the use of a direct cooling step, as claimed. Imaeda instead discloses maintaining the temperature of a lower furnace to be within a uniform temperature range of 500-1000°C to prevent rapid cooling of the single crystal. For example, Imaeda discloses that the occurrence of cracks and deterioration of the crystallinity of single crystals are caused by thermal stresses acting upon the crystal when being drawn from the growing furnace and rapidly exposed to an atmosphere of around room temperature (column 8, lines 1-6 of Imaeda).

In contrast to the disclosure in Imaeda, pending claim 1 now recites that a cooling mechanism directly cools the oxide single crystal while the single crystal is being drawn from the opening of the crucible. As such, the cooling mechanism actively extracts heat from the single crystal. Since Imaeda discloses actively maintaining a uniform temperature range (e.g., the lower furnace adds heat to the system) to prevent rapid cooling of the single crystal, Imaeda fails to disclose or suggest "providing a cooling mechanism" to directly cool the single crystal while the single crystal is being drawn from the opening of the crucible, as is recited in pending claim 1.

Nor could Imaeda's heating elements be considered to operate as cooling mechanisms. As explained above, Imaeda's heaters operate to actively maintain a specified temperature range to prevent the single crystals from being exposed to, for example, room temperature. Therefore, since Imaeda's heaters actively add heat to the system, Imaeda's

heaters are incapable of extracting heat from the system. There is simply no mechanism disclosed in Imaeda that ***actively*** removes heat from Imaeda's single crystal.

Moreover, skilled artisans would also understand that merely providing a temperature gradient between upper and lower furnaces (i.e., the upper furnace is maintained at a higher temperature) is not the same as providing a cooling mechanism to directly cool the crystal, which, as explained above, actively extracts heat from the system. That is, Imaeda employs heating elements to prevent defects in the single crystal when the single crystal is cooled too rapidly to room temperature, which, as explained above, is a process of adding heat to maintain the desired temperature of the system.

The simple fact of the matter is that, if the lower furnace were removed from Imaeda et al., the crystal would cool much more quickly (see column 8, lines 1-6). By logical definition, therefore, the lower furnace acts as a heating device, not a cooling device.

In view of the foregoing, reconsideration and withdrawal of the §102 rejection over Imaeda are respectfully requested.

2. Claims 3, 5, 7 and 9 were rejected under §103(a) over Imaeda in view of Ciszek et al. This rejection is respectfully traversed.

During the above-mentioned telephonic interview, the Examiners argued that column 5, lines 15-20 of Ciszek discloses a cooling technique that includes flowing an inert gas in different controlled amounts to different segments of the liquid-solid crystal interface so as to maintain the desired growth temperature across the growing body's interface. The Examiners argued that this teaching, combined with Imaeda, would render obvious the "cooling mechanism for directly cooling said oxide single crystal" limitation of claim 1. Applicants respectfully disagree.

There would have been no motivation to combine the teachings of Ciszek and Imaeda as asserted by the PTO. In fact, Imaeda explicitly teaches away from the use of such a direct

cooling step.[1] Again, Imaeda discloses that the occurrence of cracks and deterioration of the crystallinity of single crystals are caused by thermal stresses acting upon the single crystal when rapidly exposed to an atmosphere of around room temperature (column 8, lines 1-6). Skilled artisans would have to blindly ignore Imaeda's admonishment of the ill effects of allowing the single crystal to cool too rapidly to room temperature, let alone providing an active cooling mechanism to directly cool the crystal, before even considering (Applicants submit that skilled artisans would not do this) incorporating Ciszek's cooling technique into the method of producing oxide single crystals disclosed in Imaeda. Again, there would have been no motivation to do this, especially since Imaeda teaches that defects are likely to occur in the single crystals upon exposure to room temperature, let alone a cooling gas applied directly to the single crystals, as disclosed in Ciszek.

In view of the foregoing, reconsideration and withdrawal of the §103 rejection over Imaeda in view of Ciszek are respectfully requested.

4. Claims 3, 5, 7 and 9 were rejected under §103(a) over Imaeda in view of Berkman et al. This rejection is respectfully traversed.

Berkman discloses a method of growing ribbon crystals. Growth of the ribbon crystals is stabilized through application of coolant on the surface of a susceptor without the coolant being applied directly on the crystal (column 3, lines 54-57). Figs. 1 and 2 of Berkman illustrate that the coolant is delivered through orifices 50 to flow onto the bottom of the susceptor, and does not flow directly on the crystal or around the nozzle portion of Berkman's susceptor.

The PTO is arguing that skilled artisans would have been motivated to incorporate Berkman's cooling technique into the method of Imaeda because "excessive strain due to the

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[1] "A reference may be said to teach away when a person of ordinary skill, upon reading the reference, would be discouraged from following the path set out in the reference, or would be led in a direction divergent from the path that was taken by the applicant." (See *In re Gurley*, 31 USPQ2d 1130 (CA FC 1994))

effects of thermal shock is avoided and stabilization of the ribbon growth is achieved" (see page 5 of the Office Action).

Again, as discussed above, Imaeda explicitly discloses that rapid cooling of the single crystals must be prevented to prevent the occurrence of cracks and deterioration of the crystallinity of the single crystals (column 8, lines 1-6). As such, Applicants respectfully submit that skilled artisans would not have found it obvious to incorporate Berkman's active cooling step into Imaeda's method of growing single crystals.

Moreover, claim 3 recites that the oxide single crystal is cooled by blowing a cooling medium thereon. Berkman, however, explicitly discloses that Berkman's coolant is not applied directly to the crystal (column 3, lines 54-57). Therefore, even if skilled artisans were to ignore Imaeda's warnings concerning the rapid cooling of single crystals and attempt to combine Berkman with Imaeda as asserted in the Office Action, the resultant process would still not entail cooling an oxide single crystal by blowing a cooling medium thereon.

In view of the foregoing, reconsideration and withdrawal of the §103(a) rejection over Imaeda in view of Berkman are respectfully requested.

5. Claims 1-9 were rejected under §103(a) over Berkman in view of Machida et al. To the extent that this rejection might be applied against the amended claims, it is respectfully traversed.

As explained above, Berkman does not disclose or suggest providing a cooling mechanism for directly cooling oxide single crystals while the single crystals are being drawn from the opening of the crucible, as is recited in pending claim 1. Again, Berkman discloses flowing coolant on a portion of the susceptor, without a step of "directly cooling" the crystal, as is evidenced by the explicit disclosure in Berkman that the coolant is not to be applied directly to the crystal. Therefore, since the PTO is relying upon Machida only for the disclosure of a raw material of an oxide single crystal, Machida does not remedy the deficient

disclosure of Berkman. Consequently, even if Berkman and Machida were combined as asserted in the Office Action, the resultant process would still fail to disclose or suggest "providing a cooling mechanism for directly cooling said oxide single crystal while said oxide single crystal is being drawn from said opening of said crucible," as is recited in pending claim 1. In fact, similar to Imaeda, discussed above, Berkman explicitly teaches away from directly cooling the oxide single crystal.

In view of the foregoing, reconsideration and withdrawal of the §103(a) rejection over Berkman in view of Machida are respectfully requested.

If Examiner Song or SPE Utech believe that further contact with Applicants' attorney would be advantageous toward the disposition of this case, they are herein requested to call Applicants' attorney at the phone number noted below.

The Commissioner is hereby authorized to charge any additional fees associated with this communication or credit any overpayment to Deposit Account No. 50-1446.

Respectfully submitted,

November 5, 2002
Date

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Appl'n No.: 09/854,924

1. (Amended) A process for producing an oxide single crystal, said process comprising the steps of melting a raw material of said oxide single crystal in a crucible, contacting a seed crystal to a melt of the raw material, drawing said melt from an opening of said crucible by pulling down the seed crystal, growing the oxide single crystal, and providing a cooling mechanism for directly cooling said oxide single crystal~~,~~ while ~~it~~said oxide single crystal is being drawn from said opening of said crucible.

2. (Amended) A process for producing an oxide single crystal according to claim 1, wherein said oxide single crystal is cooled by removing ambient heat ~~thereof~~therefrom.

3. (Amended) A process for producing an oxide single crystal according to claim 1, wherein said oxide single crystal is cooled by blowing a cooling medium ~~thereto~~thereon.

VERSION WITH MARKINGS TO SHOW CHANGES MADE
Amended claims

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Paragraph [0002] has been amended as follows:

[0002] A single crystal of lithium potassium niobate and a single crystal of lithium potassium niobate-lithium potassium tantalate solid solution have been noted especially as single crystals for blue light second harmonic generation (SHG) devices for ~~a~~ semiconductor lasers. The SHG devices ~~can emit even the~~are capable of emitting ultraviolet light~~s~~ having ~~the~~ wavelengths of 390nm, thus the crystals can be suitable for wide applications such as optical disk memory, medicine and photochemical fields, and various optical measurements by using such short-wavelength lights. Since the above single crystals have a large electro-optic effect, they can be also applied to optical memory devices using their photo-refractive effect.

Paragraph [0006] has been amended as follows:

[0006] NGK Insulators, Ltd. suggested a μ pulling-down method for growing the above single crystal with ~~a~~ constant compositional proportions, for example, in JP-A-8-319191. In this method, a raw material, for example, comprising lithium potassium niobate is put into a platinum crucible and melted, and then the melt is pulled out downwardly gradually and continuously through a nozzle attached to the bottom of the crucible. The μ pulling-down method can grow a single crystal more rapidly than the CZ method or the TSSG method ~~does~~. Moreover, the compositions of the melt and the grown single crystal can be controlled by growing the single crystal continuously while supplementing the raw materials for growing the single crystal to the raw material melting crucible.

VERSION WITH MARKINGS TO SHOW CHANGES MADE
Amended specification paragraphs

Paragraph [0007] has been amended as follows:

[0007] ~~However, there is still a l~~Limitations exist in using the μ pulling-down method to grow a good single crystal plate (a planar body of a single crystal) continuously at a high rate.

Paragraph [0008] has been amended as follows:

[0008] The present inventors ~~tried to~~ formed a shoulder portion of a single crystal by adjusting the temperature of the melt, the ambient temperature around a fiber, etc. when an oxide single crystal fiber (seed crystal) was firstly contacted to a melt and then the melt was pulled down. The width of the shoulder portion is gradually enlarged, and when it reaches the desired size, temperatures of such as a nozzle portion are slightly raised to stop the increase in width of the shoulder portion. After that, a planar body having a uniform width is continuously pulled down following a terminal end of the shoulder portion. According to this method, cracks are ~~hard to~~inhibited from progressing from near a joint interface of the seed crystal and the planar body.

Paragraph [0011] has been amended as follows:

[0011] The present invention relates to a process for producing an oxide single crystal, ~~said~~the process ~~comprising~~includes the steps of melting a raw material of ~~said~~the oxide single crystal in a crucible, contacting a seed crystal to a melt of the raw material, drawing the melt from an opening of the crucible by pulling down the seed crystal, growing the single crystal, and cooling the oxide single crystal~~;~~ while ~~it~~the single crystal is being ~~pulling~~pulled down from the opening of the crucible.

VERSION WITH MARKINGS TO SHOW CHANGES MADE
Amended specification paragraphs

Paragraph [0012] has been amended as follows:

[0012] The present invention also relates to an apparatus for producing an oxide single crystal ~~comprising~~including a crucible for melting a raw material of ~~said~~the oxide single crystal and a cooler.~~,~~ ~~wherein said~~ The crucible has an opening and ~~said~~the cooler is provided at least under ~~said~~the opening of the crucible to cool ~~said~~the oxide single crystal~~,~~ while it is drawn from ~~said~~the opening of the crucible.

Paragraph [0013] has been amended as follows:

[0013] The present inventors ~~had~~ examined various methods to prevent the above cracks extending perpendicularly in the crystal. The present inventors firstly investigated the cause of occurring the cracks lengthwise, and found that a dimensional change occurred in the planar single crystal. That is, the width of the planar single crystal near the opening of the crucible was larger than that in an anneal region apart downwardly from that opening by, for example, about 0.5%. This was caused by a thermal expansion of the oxide single crystal. It is more likely that such dimensional change in the width of the planar single crystal generates a thermal stress in the crystal, thus ~~causes~~causing the cracks in the single crystal extending ~~in~~ perpendicularly.

Paragraph [0021] has been amended as follows:

[0021] In a preferred embodiment of the present invention, the cooler has path for flowing a cooling medium and the cooling medium removes the ambient heat around the cooler.

VERSION WITH MARKINGS TO SHOW CHANGES MADE
Amended specification paragraphs

The heading on page 7, line 1 has been amended as follows:

DETAILED DESCRIPTION OF THE INVENTION~~PREFERRED EMBODIMENT~~

VERSION WITH MARKINGS TO SHOW CHANGES MADE
Amended specification paragraphs

Please replace paragraph [0002] with the following rewritten paragraph:

B3

[0002] A single crystal of lithium potassium niobate and a single crystal of lithium potassium niobate-lithium potassium tantalate solid solution have been noted especially as single crystals for blue light second harmonic generation (SHG) devices for semiconductor lasers. The SHG devices are capable of emitting ultraviolet light having wavelengths of 390nm, thus the crystals can be suitable for wide applications such as optical disk memory, medicine and photochemical fields, and various optical measurements by using such short-wavelength lights. Since the above single crystals have a large electro-optic effect, they can be also applied to optical memory devices using their photo-refractive effect.

Please replace paragraph [0006] with the following rewritten paragraph:

B4

[0006] NGK Insulators, Ltd. suggested a μ pulling-down method for growing the above single crystal with constant compositional proportions, for example, in JP-A-8-319191. In this method, a raw material, for example, comprising lithium potassium niobate is put into a platinum crucible and melted, and then the melt is pulled out downwardly gradually and continuously through a nozzle attached to the bottom of the crucible. The μ pulling-down method can grow a single crystal more rapidly than the CZ method or the TSSG method. Moreover, the compositions of the melt and the grown single crystal can be controlled by growing the single crystal continuously while supplementing the raw materials for growing the single crystal to the raw material melting crucible.

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Please replace paragraph [0007] with the following rewritten paragraph:

B5

[0007] Limitations exist in using the μ pulling-down method to grow a good single crystal plate (a planar body of a single crystal) continuously at a high rate.

Please replace paragraph [0008] with the following rewritten paragraph:

B6

[0008] The present inventors formed a shoulder portion of a single crystal by adjusting the temperature of the melt, the ambient temperature around a fiber, etc. when an oxide single crystal fiber (seed crystal) was firstly contacted to a melt and then the melt was pulled down. The width of the shoulder portion is gradually enlarged, and when it reaches the desired size, temperatures of such as a nozzle portion are slightly raised to stop the increase in width of the shoulder portion. After that, a planar body having a uniform width is continuously pulled down following a terminal end of the shoulder portion. According to this method, cracks are inhibited from progressing from near a joint interface of the seed crystal and the planar body.

Please replace paragraph [0011] with the following rewritten paragraph:

B7

[0011] The present invention relates to a process for producing an oxide single crystal, the process includes the steps of melting a raw material of the oxide single crystal in a crucible, contacting a seed crystal to a melt of the raw material, drawing the melt from an opening of the crucible by pulling down the seed crystal, growing the single crystal, and cooling the oxide single crystal while the single crystal is being pulled down from the opening of the crucible.

Substitute specification paragraphs

Please replace paragraph [0012] with the following rewritten paragraph:

B8

[0012] The present invention also relates to an apparatus for producing an oxide single crystal including a crucible for melting a raw material of the oxide single crystal and a cooler. The crucible has an opening and the cooler is provided at least under the opening of the crucible to cool the oxide single crystal while it is drawn from the opening of the crucible.

Please replace paragraph [0013] with the following rewritten paragraph:

B9

[0013] The present inventors examined various methods to prevent the above cracks extending perpendicularly in the crystal. The present inventors firstly investigated the cause of occurring the cracks lengthwise, and found that a dimensional change occurred in the planar single crystal. That is, the width of the planar single crystal near the opening of the crucible was larger than that in an anneal region apart downwardly from that opening by, for example, about 0.5%. This was caused by a thermal expansion of the oxide single crystal. It is more likely that such dimensional change in the width of the planar single crystal generates a thermal stress in the crystal, thus causing the cracks in the single crystal extending perpendicularly.

Please replace paragraph [0021] with the following rewritten paragraph:

B10

[0021] In a preferred embodiment of the present invention, the cooler has path for flowing a cooling medium and the cooling medium removes the ambient heat around the cooler.

Substitute specification paragraphs

Appl'n No.: 09/854,924

Please replace the heading on page 7, line 1 with the following rewritten heading:

B11

DETAILED DESCRIPTION OF THE INVENTION

Substitute specification paragraphs